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Projecting Food Demand: A Comparison of Two Methods

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ABSTRACT

Results of food demand projections based on national aggregate data are compared to those based on micro, or subnational, data sources. Sri Lanka data for 1969/70 were used as a case study. Both projection methods give similar results for total food demand. For individual commodities, aggregate projections are smaller than micro projections, with the exception of rice and vegetables. Micro projections may be more reliable because more factors underlying demand are taken into account. If used in development planning, the results of these projection procedures would lead to very different food production strategies.

Keywords: Food demand, projections, commodity demand, total food demand, production policies, planning strategies

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PREFACE

In many developing countries, the average quantity and quality of food are barely adequate, with sizable segments of the population having inadequate diets. Yet, the market demand for food in developing countries is little understood. The few studies available have focused on one or a few large aggregate commodity groups. Comprehensive studies of food demand that consider specific commodities are rare and largely confined to highly developed economies.

The problem of poor diets in developing countries is widespread and persists despite substantial development efforts on the part of many governments, including the U.S. Government. A contributing factor has been the lack of information on the food demand and consumption behavior of specific consumer groups. Information that does exist is usually derived from national aggregate data and thus limited to the calculation of a national average for one or a few large commodity aggregates. The result is that analysis of the potential impact of food policy decisions on the consumption of specific commodities by specific consumers cannot be done.

An additional problem has been the lack of appropriate data. Food demand analysis has traditionally relied on time series data. However, the amount of detailed data needed to estimate the structure of food demand is much greater than what is normally available in most developing countries. An alternative data source is available for those developing countries which have undertaken national household food consumption and expenditure surveys. These surveys contain the detailed information needed for highly disaggregated analysis of food demand.

The current work in food demand and consumption in developing countries by the Agricultural Development Branch, International Economics Division, Economic Research Service helps to increase the knowledge available on the structure of food demand in developing countries. The goal is to generate additional knowledge for use in programming U.S. food aid and development assistance, and to improve the accuracy of global food demand projections.

The current objective of the research is to develop a procedure to analyze food demand as a comprehensive system. This requires that the analysis be sufficiently disaggregated so that meaningful policy relevant information is generated regarding the consumption of specific foods by specific segments of the population. Only with detailed information at this level is it possible to make adequate *a priori* analysis of the potential impact of food policy changes, or to plan agricultural projects to fill these specific food needs.

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INTRODUCTION

Adequate food supplies remain a serious problem in many developing countries. Often the choice lies between use of scarce foreign exchange to import needed food vs expansion of capital inputs required to increase domestic food production. Shortfalls in food supplies will cause nutritional problems and may bring political instability, but failure to make necessary investments in agriculture will have long-term consequences for food import imbalances. Knowledge of future food demand levels would provide information needed for improved development planning and decisionmaking.

METHODOLOGY

This report compares the results of two projection techniques: aggregate and micro. Aggregate projections, the technique usually employed, rely on a single income elasticity value with the income level based on trend or assumption. The micro projection technique developed in this report takes into account several factors generally acknowledged to underlie market demand. Since these factors can be independently projected, the projected results may be more accurate and useful than typical food commodity projection techniques with the accuracy dependent upon the accuracy of the projected underlying factors. The projected results of the two procedures for the years 1990 and 2000 are compared for total food demand and for the demand for individual commodities.

Aggregate Projection

Projections of food demand normally used are based upon national aggregate data, where the change factors in the equation are real income growth rate and time. Such an equation may be written as:

$$q_{it} = q_{io}(1 + e_{iy}s_y)^t, \qquad [1]$$

where e_{iy} is the income elasticity of the ith commodity and is assumed to be constant throughout the projection period,

s_y is the rate of real income growth,

q_{io} is the initial per capita consumption of the ith commodity, and

q_{it} is the projected per capita consumption of the ith commodity at time t.

Total demand is then simply the multiplication of the per capita commodity consumption by the population at time t, that is:

$$Q_{it} = q_{it} \times P_t, \qquad [2]$$

where q_{it} is defined as above,

P_t is the projected population at time t, and

Q_{it} is the projected total demand at time t.

The population at time t is projected using the following equation:

$$P_t = P_o(1 + R)^t, \qquad [3]$$

where R is the rate of natural population growth,

P_o is the initial population, and

P_t is the projected population at time t.

Micro Projection

To the extent that food demand is in reality determined by factors in addition to changes in population and real income, the equation used above for the aggregate projections may not give accurate results. The aggregate projection results will also be inaccurate to the extent income elasticity changes during the projection period, or if household income changes are unevenly distributed through the population.

These issues can be addressed if demand elasticity estimates are available by consumer group within the population. Such estimates have been developed and reported elsewhere (7, 2, and 6).1/ The parameter estimates and consumer group summation procedures developed by these researchers are used in this report to extend and refine the aggregate projection equation to reflect both additional information and changes over time in the income elasticity of demand, and income and population distribution.

Micro Demand Elasticities Aggregated to the National Level

Given income elasticity estimates for each consumer group, the national aggregate income elasticity can be calculated by the weighted summation over the groups. The weights are the share of population and budget proportion for each commodity within each consumer group.

$$E_{iy} = \frac{\sum_g E_{giy} P_g W_{gi}}{\sum_g P_g W_{gi}} \qquad [4]$$

1/ Numbers in parenthesis refer to items cited in References.

where E_{iy} is the income elasticity of demand at the national aggregate level for commodity i,

E_{giy} is the income elasticity of demand of group g for commodity i,

P_g is the population of group g,

W_{gi} is the proportion of budget spent on commodity i by group g.

These components, used in the calculation of aggregate elasticity values, can now be related to the initial discussion of the assumptions underlying projection work. First, the complete matrix of elasticities represented by own- and cross-price elasticities, e_{gij}, and the income elasticity, e_{giy}, together form the basic food demand structure of a particular consumer group, g. These matrices have been estimated and reported by (7). It is this structure for group g which is presumed to remain constant throughout the projection period. Changes in consumption levels within this structure result from relative price changes and/or income changes, not from changes in the elasticity values within the matrix. However, changes in the aggregate elasticity values occur over time as the weighting factors change; that is, as changes occur in the share of population associated with each consumer group. Households moving into a new consumer group are assumed to adopt a consumption pattern consistent with that group's demand structure, as represented by the appropriate elasticity matrix.

In this case study of Sri Lanka, population was shifted among consumer groups in a manner consistent with historical population shifts and projected increases. Average budget share within each group for each commodity was assumed constant.

Projected Aggregate Demand Elasticities

Changes over time in factors affecting demand elasticities at the aggregate level were projected using the following equation. The projected income elasticity at time t becomes:

$$E_{iyt} = \frac{\sum_g E_{giy} P_{gt} W_{gi}}{\sum_g P_{gt} W_{gi}} \qquad [5]$$

where E_{iyt} is the projected income elasticity of demand for commodity i at time t,

E_{giy} is the estimated income elasticity for commodity i for consumer group g,

P_{gt} is the projected population of consumer group g at time t, and

W_{gi} is the budget proportion for commodity i for consumer group g.

Shifts and Growth in the Population

The importance of investigating food demand by specific consumer groups within a market economy has been shown in other work.2/ But within an economy, not only is there overall population growth, but there are also shifts in the relative share of population among consumer groups. Likewise, the structure of food demand changes with income level. The previous research upon which this study is based divided consumer households into rural and urban sectors and by five income levels within each sector, for a total of 10 consumer groups.

Changes in population of a specific consumer group over time are the net effects of the following factors:

(1) Natural growth deriving from the difference between the birth rate and death rate.

(2) Migration from one geographical area to another, primarily from rural to urban areas.

(3) Shifts from one income group to another which occurs when a household income change moves that household into a different income bracket.

The rate of population change for consumer subpopulation group g is projected using the following equation:

$$P_{gt} = P_{go}\,(1+r_{gn}+ r_{gm}+ r_{gy})^{t}, \qquad [6]$$

where r_{gn} is the natural rate of population growth in group g,

r_{gm} is the net migration rate of population change in group g, with r_{gm} being positive if group g is experiencing inmigration, negative if group g is experiencing out-migration, and

r_{gy} is the net rate of population shift into the net income group due to an increase in household income.

CASE STUDY: SRI LANKA

Sri Lanka was selected as a case study for the comparison of the aggregate and micro projection procedures. Complete food demand elasticity matrices have been previously estimated and reported for five income groups in both rural and urban areas, based upon data from the 1969/70 Socio-Economic Survey of Sri Lanka (3).3/

2/ The work reported in this paper is an extension of the work reported in (7, 2, and 6).

3/ Details of the procedures used to estimate the demand parameters have been reported in (2, 6). The elasticities used in this study are those estimated in (7) using the OLS estimation procedure.

The five groups studied in rural and urban areas are:

Rural and urban consumer group	Rs./household/month 4/
1	below 200
2	200 - 399
3	400 - 599
4	600 - 799
5	above 800

Projected Population by Consumer Group

The existing population during the socioeconomic survey of 1969/70 serves as a base for the projections. The number of persons in each income group for rural and urban areas was reported by the Department of Census and Statistics of Sri Lanka (3).

The rate of population growth for each category depends upon the rate of natural population increase, the migration rate of population from one geographical area to another, and the shift from one income category to another. For the natural rate, it was assumed that the population grows at a rate of 2.3 percent per year. This figure was obtained from work published by the Central Bank of Ceylon in 1979 (4).5/ For simplicity, this value was applied to all groups in both rural and urban areas.

The rate of migration between geographic areas was deduced from data on the rural and urban population published in the Sri Lankan statistical abstract of 1979 (4). The ratio of rural to urban population was calculated for each period reported and then an estimate of the migration rate was derived. On average, the migration rate from rural to urban areas was 1.2 percent per year.

Attempts were made to estimate the rate of migration between geographic areas within each income category. However, no data were available to support such an estimation. Thus, it was simply assumed that all income groups in rural areas have an outmigration rate of -1.2 percent (national average). Urban to rural migration was assumed to be negligible.

The population shift from one income level to the next higher level is due to the change in the real income of households. Since the aggregate rate of per capita real income growth has historically been 1.1 percent, it was assumed here that 1.1 percent of the people in income level 1 would move to income level 2.6/ At the same time, 1.1 percent of the people at the latter level would move to income level 3. The process continues as households in income

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4/ These income categories reflect real income since real income is used to determine the number of households moving into a category.

5/ The Central Bank of Ceylon reports that the annual rate of the population growth has varied between 2.8 percent and 1.8 percent during the past three decades. The population series on Sri Lanka published by the U.S. Bureau of Census, however, shows a 1.7-percent rate of growth for the period 1967-83.

6/ This rate was reported by the Central Bank of Ceylon. However, the growth rate of real GDP published by the International Monetary Fund was 4.5 percent per year from 1967-83. With population growing at an annual rate of 2.3 percent assumed in this study, the real per capita income growth rate would be 2.2 percent annually.

level 4 move to level 5. Hence, each year, the low income rural consumer group would lose 1.1 percent of its population, while the upper income urban group would experience a net gain due to the combination of income changes and migration. All other consumer groups would have a net gain or loss in their population according to the number of households who moved out and the number of households from the next lower income level who moved in during a given year. The net rates of shift between consumer groups are given in table 1, expressed in terms of the percentage of population of the group considered.7/

Using the rates in table 1, projections of population for each consumer group were made for 1990 and 2000. These results are presented in table 2. The population in rural income group 1 appears to be constant throughout the projection period because the assumed rate of natural increase (2.3 percent) is equal to the sum of the assumed rates of outmigration and of income shift from that group. In both rural and urban areas, income group 4 shows the largest increase due to the large population found in the next lower group.

Table 1--Base population 1969/70 and net rate of population shift between consumer groups

Consumer group	Base population (1969/70)	Net rate of population shift
	Number	Percent
Rural:		
1	3,222,581	-1.10
2	3,396,976	-.06
3	1,240,036	1.90
4	415,574	2.18
5	237,953	1.92
Urban:		
1	334,640	-1.10
2	832,149	-.66
3	413,261	1.11
4	198,464	1.19
5	317,535	.69

Source: Department of Census and Statistics, Sri Lanka.

7/ This simplifying assumption does not mean that income is evenly distributed throughout the population, but only that future gains will be evenly distributed across income groups. However, under the micro projection procedure, these gains do not result in the same change in consumption because the absolute changes in income elasticity values differ by consumer group (see equation 5). Given appropriate data or informed judgment of relative distribution, the assumption of evenly distributed future income gains can be relaxed and used to improve the projections.

Table 2--Projected population by consumer group 1/

Consumer group	Population 1990	Population 2000
	Number	
Rural:		
1	3,222,581	3,222,581
2	4,105,944	4,460,428
3	2,061,458	2,530,659
4	771,368	1,021,000
5	433,915	585,494
Urban:		
1	1,293,078	1,865,174
2	2,244,318	3,247,377
3	1,305,748	2,067,888
4	591,488	965,713
5	688,476	1,020,687
Total	16,718,374	20,987,001

1/ The values listed are based on equation 6.

Projected Aggregate Income Elasticity Values

The appropriate consumer group population figures, budget proportion, and estimated income elasticity values can now be used to project the aggregate income elasticity value at time t. The results for 1990 and 2000 are shown in table 3.

Income (expenditure) elasticities of most food commodities became more inelastic over the projection period (table 3). This means that as the income of consumers increases through the years, the incremental increase in consumption of those foods becomes smaller. For instance, the income elasticity of rice decreases from 0.57 in 1969/70 to 0.51 in year 2000, sugar from 0.52 to 0.45, and cooking oil from 0.78 to 0.72. Some commodities, including spices, baked goods, fruits, and eggs, show a gain in income elasticity values over time.

Projected Food Demand Using Aggregate Data

The Sri Lankan diet during the late 1960's and early 1970's was based on rice. Rice supplied the largest proportion of calories and represented the largest expenditure in the food budget. Spices, bakery goods, fish, and vegetables also contribute importantly to the diet and to food expenditure. Sri Lanka's food policy during this period was heavily oriented toward consumption. A weekly free ration of 2 pounds rice per capita was the cornerstone of this policy.8/

8/ The elasticity values used in this study are based on the market demand for rice over and above this free ration.

Table 3--Projected income elasticity values 1/

Commodity	1969/70 (base)	1990	2000
Rice	0.57	0.53	0.51
Spices	.46	.48	.48
Baked goods	.29	.38	.39
Fish	.56	.55	.55
Vegetables	.46	.45	.44
Sugar	.52	.48	.45
Fruit	.35	.37	.39
Other grains	.13	.13	.13
Milk	.62	.61	.60
Meat	.68	.57	.55
Cooking oil	.78	.74	.72
Eggs	.61	.65	.65

1/ The values listed are based on equation 5.

In the illustrative case study of Sri Lanka used in this report, population was projected from the 1970 value using a natural growth rate of 2.3 percent. The rate of real income growth used was a long-term historical average of 1.1 percent. The income elasticity values were estimated during analysis of the 1969-70 Socio-Economic Survey (3). Initial consumption per capita was taken from the 1970 FAO Food Balance Sheet (5) for the projection of all food, and from the 1969-70 Socio-Economic Survey (3) for individual commodities.

Two types of aggregate projections were made to the years 1990 and 2000. The first projects demand for all food by converting total calorie consumption to metric tons of rice equivalent for the 1970 base period, then projecting consumption in rice equivalents. The income elasticity used was the estimated value for all food, E_{fy}, as calculated in equation 7. The resulting projections are shown in table 4.

$$E_{fy} = \frac{\sum_i W_i E_{iy}}{\sum_i W_i} \qquad [7]$$

The second type of aggregate projection focused on commodity groups. In this case, per capita consumption and the elasticity values were estimated from the 1969-70 Socio-Economic Survey (3). The projected levels for each commodity group are shown in table 5. The levels assume the elasticity values to be constant throughout the projection period.

Projection of Food Demand Using Micro Data

Total food demand was projected using the two different procedures. First, food demand in rice equivalents was projected to 1990 and 2000 for each

Table 4--Aggregate projection of total consumption

Year	Rice equivalent
	Metric tons
Base year 1970 1/	2,620,524
1990	4,587,708
2000	6,073,081

1/ Total consumption taken from (5).

Table 5--Aggregate projection of individual commodities

Commodity	1990	2000
	Metric tons	
Rice	1,104,584	1,476,532
Spices	548,829	724,918
Baked goods	672,684	872,205
Fish	276,029	368,352
Vegetables	909,402	1,200,890
Sugar	864,563	1,149,312
Fruit	1,532,305	1,998,960
Other grains	410,372	522,490
Milk	92,413	124,201
Meat	154,996	209,674
Cooking oil	48,450	66,238
Eggs	54,681	73,393

consumer group with total demand as the sum of the group. Total demand increases from 2.565 million metric tons of rice equivalent in 1969/70 to 4.498 million metric tons in 1990, and to about 5.944 million metric tons in 2000 (table 6).

The projected demand for specific commodities is shown in table 7. These demand levels are also the sum of the consumer groups. Hence, the projected levels in table 7 take into account urbanization and population and income shifts.

Table 6--Projected total consumption by summation over consumer groups

Consumer group 1/	Base year 1969/70	1990	2000
	Metric tons, rice equiv.		
Rural:			
1	703,271	803,726	860,186
2	783,366	1,037,229	1,179,527
3	349,101	620,305	787,723
4	121,514	235,713	319,039
5	84,647	164,524	229,284
Urban:			
1	66,727	281,863	425,084
2	190,745	568,262	864,315
3	106,267	366,313	606,163
4	55,945	181,739	309,870
5	104,171	238,327	362,976
Total	2,565,754	4,498,001	5,944,167

1/ Analysis is based on data from (3).

Table 7--Projected demand for commodities by summation over consumer groups

Commodity	1990	2000
	Metric tons	
Rice	1,051,389	1,366,050
Spices	557,644	741,717
Baked goods	733,890	992,978
Fish	291,632	395,951
Vegetables	877,713	1,141,801
Sugar	878,861	1,171,476
Fruit	1,643,373	2,227,545
Other grains	411,317	527,435
Milk	99,073	136,949
Meat	167,789	233,176
Cooking oil	51,137	71,227
Eggs	63,645	91,407

The projections of food demand were made by two basic methods: one based on national aggregate data, the other on micro (household survey) data. Each method was then used to make two additional projections: overall food demand in rice equivalents and total demand for individual commodities.

The comparison of results for the basic projection methods for total food demand in metric tons of rice equivalent are shown in table 8. These data indicate the differences are small. The values based upon aggregate data are slightly higher than those based upon the micro data source and probably reflect small differences in the basic data sources. However, with respect to total food demand in rice equivalents, the two methods give highly similar results.

The comparisons of results for total demand for individual commodities are shown in table 9. These results show projections based on aggregate data for total demand values are less for most commodities than for the corresponding projection based on micro data. The magnitude of these underestimates in year 2000 range from 228,585 metric tons for fruit, down to 4,945 metric tons for other grains. In percentage terms, the largest underestimate is for eggs at 19.7 percent, down to 0.9 percent for other grains (see table 9).

The exceptions are rice and vegetables. These foods were staples in the Sri Lankan diet at the time of the survey and were by far the most important sources of calories. Compared with the micro projection for rice demand, the projected aggregate value is 110,482 metric tons larger in year 2000. The comparable value for vegetables is 59,089 metric tons. In the projection of total food, the larger projected values for rice and vegetables offset the smaller projections for the remaining foods such that the overall rice equivalent values are nearly equal for the aggregate and micro projections.

Table 8--Comparison of projected total food demand from aggregate and micro sources

Item	Base year 1969/70		1990		2000	
	Aggregate	Micro	Aggregate	Micro	Aggregate	Micro
	Million metric tons (rice equiv.)					
Total demand	2.62	2.57	4.59	4.50	6.07	5.94
Difference 1/	+.05		+.09		+.13	
Adjusted difference 2/	0		+.04		+.09	

1/ Difference = aggregate - micro.
2/ Adjusted difference = difference - 0.05 million metric tons (rice equivalent).

Table 9--Comparison of projected commodity totals

Commodity	Projection procedure and year				Difference 1/		Relative difference 2/	
	Aggregate		Micro		1990	2000	1990	2000
	1990	2000	1990	2000				
	Metric tons							
	1,104,584	1,476,533	1,051,389	1,366,050	53,195	110,482	.0505	.0808
Spices	548,829	724,918	557,644	741,717	-8,815	-16,799	-.0158	-.0226
Baked goods	672,684	872,205	733,890	992,978	-61,206	-120,773	-.0833	-.1216
Fish	276,029	368,352	291,632	395,951	-15,603	-27,599	-.0535	-.0697
Vegetables	909,402	1,200,890	877,713	1,141,801	31,689	59,089	.0361	.0517
Sugar	846,563	1,149,312	878,861	1,171,476	-32,298	-22,164	-.0367	-.0189
Fruit	1,532,305	1,998,960	1,643,373	2,227,545	-111,068	-228,585	-.0675	-.1026
Other grains	410,372	522,490	411,317	527,435	-945	-4,945	-.0022	-.0093
Milk	92,413	124,201	99,073	136,949	-6,660	-12,748	-.0672	-.0930
Meat	154,996	209,674	167,789	233,176	-12,793	-23,502	-.0762	-.1007
Cooking oil	48,450	66,238	51,137	71,227	-2,687	-4,989	-.0525	-.0700
Eggs	54,681	73,393	63,645	91,407	-8,964	-18,014	-.1408	-.1970

1/ Difference = aggregate - micro.
2/ Relative difference = difference/micro.

However, development and agricultural and food policy planning must be made on a commodity basis, because it is individual commodities that are produced, imported/exported, and consumed. Therefore, the results of interest in this report lie in the direction and magnitude of the differences in projected values for individual commodities.

As noted, the aggregate data project larger values for the food groups rice and vegetables. These foods must be considered as staples in the diet. By comparison, all other commodities are consumed less, and are more expensive sources of calories. These other foods then are more preferred in that they command higher market prices. It is these preferred food categories where the total commodity demand is consistently underestimated by the aggregate data projection method. In terms of metric ton quantities, the largest underestimations are for bakery goods, fruit, meats, and sugar. Large relative differences are shown for baked goods, fruit, milk, and eggs.

The reason for these differences lies mainly in the structure of food demand and population shifts among consumer groups. The net population shifts and real income increases favor the expansion of demand for the preferred foods. Since the actual number of consumers moving into the middle income categories is larger than for either low or high income categories, demand for preferred food follows accordingly. It is precisely these underlying factors of demand that the aggregate projection method ignores.

IMPLICATIONS

These data suggest that total food demand can be projected quite accurately by aggregate data, but that projected demand for individual food commodity groups from aggregate data is less certain. Indeed, it seems likely that projected commodity demand based upon micro level (household level) data will be more accurate, because this projection procedure explicitly takes into account factors generally accepted as affecting market demand.

These different projection techniques suggest different food production policies and planning strategies. If aggregate projections are used, the logical strategy is to focus on production of staple foods because there is no indication that in the future other commodities will become relatively more important in total consumption.

However, commodity projections based upon micro level data imply a food production strategy wherein the relative commodity demand shifts over time away from staple foods to the more preferred commodities. This, in turn, implies the need to shift the use of land and labor for production and capital investments into the corresponding marketing and processing industries associated with the preferred commodities.

Likewise, food exporting countries interested in the emergence and magnitude of new markets will find very different market strategies flow from these two projection procedures. For example, the major growing market in the future is for staples under the aggregate projection, while the micro projections imply a substantially larger share of future food consumption will be in the more expensive preferred commodities.

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